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CARTILAGE THICKENING OCCURS IN BOTH UNLOADED AND NEW TIBIOFEMORAL CONTACT REGIONS IN INJURED SHEEP

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Purpose: Cartilage both swells and thins following joint injury, but relating these phenomena to injury-specific in vivo dynamic mechanical abnormalities remains challenging technically. Therefore, the study purpose was to investigate the spatial distribution of the morphological response of tibiofemoral cartilage to in vivo changes in contact location during dynamic gait using two injury models known to cause post-traumatic osteoarthritis (PTOA). We hypothesized that the spatial distribution of damaged cartilage thickness is injury-specific, with cartilage thickening occurring at new tibiofemoral contact regions, and cartilage thinning occurring at unloaded regions.
Methods: 14 skeletally mature female sheep underwent combined ACL/medial collateral ligament transection (ACL/MCLx; n=5), complete lateral meniscectomy (Mx; n=5), or sham arthrotomy (Sham; n=4). In vivo right hind 3D stifle kinematics during dynamic gait were recorded pre-operatively (Intact) and 20 weeks (20w) post-operatively using removable custom bone-mounted marker assemblies and an optical motion capture system. At 20w, animals were euthanized, hind limbs disarticulated, and stifle cartilage was graded and mapped. The 3D tibiofemoral articular surface geometries of 11 sheep were measured optically using stereophotogrammetry (SPG), which involved capturing a series of photographs of surface fiducial marks and control targets (Figure 1.A). With the kinematic marker assemblies affixed to the bones, SPG control targets and marker centroids were co-registered in a common 3D reference frame using a hand-held coordinate measure machine (CMM; accuracy=0.025mm). Tibiofemoral articular cartilage was then removed using a papain solution, and the bone-mounted marker assemblies re-attached. Anatomical coordinate systems (ACS) were created and subchondral bone surfaces traced using the hand-held CMM. Because the marker assemblies were always in the same relative orientation to the bone (precision=0.1±0.1mm), the articular and subchondral surface geometries could be expressed in a common ACS using the marker assemblies as reference points (registration precision=0.2±0.1mm). Subchondral bone and articular surfaces were modeled using thin plate splines (TPS), and cartilage thickness was determined as the distance from the subchondral TPS surface model to the articular surface model. In vivo contact location during dynamic gait was determined by mapping the relative position and separation of tibiofemoral subchondral bone surfaces between successive hoofstrikes, and was quantified using weighted centroids (precision=0.5±0.3mm).
Results: Cartilage was thickest over the inner regions of the tibial eminences and central regions of the femoral condyles. Contrary to previous reports, these regions of thickest femoral and tibial cartilage were not aligned during stance in sham-operated sheep. ACL/MCLx and Mx led to significantly more tibiofemoral cartilage damage than Sham (Mann-Whitney test, adjusted $p<0.017$), with anteromedial and lateral compartment regions being the most damaged in each injury model, respectively. ACL/MCLx mid-stance centroid locations were significantly different from Intact ($p<0.05$, repeated measures ANOVA; precision=1.1±0.4mm). Further, cartilage thickness became more homogeneous across the surface, with thicker regions (relative to Sham cartilage profiles) corresponding to regions of gross cartilage damage, but not weighted centroid location. Mx lateral compartment cartilage thickness also became more homogeneous across the entire surface, with cartilage thickening (tibia) and thinning (femur) at sites distant from weighted centroid locations (Figure 1.B).
Conclusions: Cartilage thickness becomes more homogeneous following stifle injury in sheep. Whereas the thickest tibiofemoral cartilage regions are not aligned during stance in uninjured sheep, the spatial agreement between individual distribution of cartilage damage and relative thickness in ACL/MCLx sheep partially confirms our hypothesis. However, the relationship between the spatial distribution of cartilage damage and sites of new contact location in this injury model remains unclear. Mx lateral compartment cartilage exhibited both thickening and thinning that was surface-specific, suggesting that potentially abrupt decreases in contact stress at sites where the meniscus once was may be equally detrimental to cartilage health. Together, **Conclusions** from these injury models support the paradigm that abnormal contact mechanics contribute to PTOA initiation and progression following stifle injury.

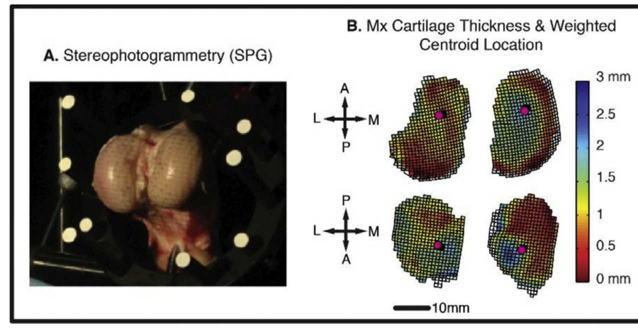

Figure 1. **A**. SPG was used to capture articular surface geometry optically. The femoral surface is visible at the centre of the custom frame with the ring of white control targets. **B.** Mx tibiofemoral cartilage thickness map and weighted centroid location at Intact (black circles) and 20w post-Mx (magenta circles) for a representative sheep. Mx centroid locatins were not statistically different (repeated measure ANOVA). Cartilage thickness (shown as a colour map, in mm) was more homogeneous across the damaged lateral compartment surfaces. Anterior, posterior, medial, and lateral orientations are indicated by capital letters on the legends to the left.

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NEUROMUSCULAR KNEE JOINT CONTROL IN ADOLESCENTS WITH AND WITHOUT GENERALISED JOINT HYPERMOBILITY DURING LANDING IN THE SINGLE LEG HOP FOR DISTANCE TEST

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Purpose: Severe knee injuries can occur due to biomechanical factors such as knee joint laxity. Generalised Joint Hypermobility (GJH) has been proposed as an intrinsic risk factor for knee injuries in adults and adolescents, as individuals with GJH often have knee joint hypermobility. Also, critical knee injuries are known to be associated with an increased risk for future development of osteoarthritis (OA).
To potentially compensate for reduced passive joint stability, adequate neuromuscular knee joint control is required before and during loading of the lower extremities. The aim of this study was to investigate differences in the neuromuscular pre and post activation landing patterns around the knee joint in adolescents with GJH and without GJH (NGJH) in the Single leg Hop for Distance test.
Methods: This study included 54 adolescents (10-15 years) from public schools, 25 with GJH and 29 with NGJH, with groups matched on age and sex. Inclusion criteria for GJH were Beighton score ≥5/9 with at least one hypermobile knee, and no current pain of the lower extremities. Bipolar surface electromyography (EMG) of the following six knee muscles; Vastus Medialis (VM), Vastus Lateralis (VL), Biceps Femoris (BF), Semitendinosus (ST), Gastrocnemius Medialis (GM) and Lateralis (GL) was used to determine pre- and post impact activation levels in % of maximal voluntary electrical activation (MVE). EMG was registered on the leg with the most hypermobile knee joint during landing in the Single leg Hop for Distance test. Group differences of EMG pre and post activation levels of the six muscles were calculated with a mixed-effects two-level regression model.
Results: There was no difference in performance of the SLHD test (p=0.67). At the first time point, i.e. 100 ms before landing, GJH pre-activated ST 30% less compared with NGJH (22.1 (±12.6) vs 31.4 (±16.6), p=0.02), conversely, GJH had a 28% higher GM pre-activity level than NGJH (32.5 (±14.8) vs 23.2 (±15.6), p=0.02). Totally for both time points, GJH had lower ST (p=0.009) muscle activity than NGJH. No difference between groups or interaction with GJH and the second time point, i.e. 100 ms after landing was seen for ST or any of the other muscles.
Conclusions: Lower ST and higher GM pre activation levels were found in adolescents with GJH and knee joint hypermobility compared with NGJH. The latter is likely a compensatory strategy to enhance joint stability. Lower hamstring pre activation may result in lower hamstring contraction force during the initial part of the ground contact, increasing the load on the anterior cruciate ligament and thereby the